

# **Satellite/NWP Data Fusion for Weather Assessment**

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Award #: N0001400WX40010 (BE-35-2-32)

## **LONG-TERM GOALS**

The long-term goal of the Satellite/NWP Data Fusion for Weather Assessment (DaFWA) project is to determine the feasibility of combining numerical weather prediction (NWP) and satellite data for the purpose of estimating tactical weather elements in data-void locations.

## **OBJECTIVES**

Our objective is to improve upon the utilization of both remotely sensed data and numerical weather prediction data in order to estimate current sensible weather (conditions) typically available by observation only. We are emphasizing this condition because many of the military's operations deal with situations where observed data are not available. The initial tactical weather element considered for study is cloud base height, particularly for low clouds.

## **APPROACH**

Data is being collected for a set of 45 coastal and inland locations in three “focus areas” (FAs): the U.S. west coast, the region surrounding the Adriatic Sea, and Korea. Data collected will consist of four components: a) NWP data, b) satellite data, c) ground truth, and d) climatology. We will use the Navy’s regional forecast model, COAMPS, the Coupled Ocean/Atmosphere Mesoscale Prediction System (run operationally at the Navy’s Fleet Numerical Meteorology and Oceanography Center, FNMOC), but using NRL’s Tactical Atmospheric Modeling System-Real Time (TAMS-RT) version run on our own workstation. Satellite data will consist of GOES, Meteosat, and GMS geostationary satellites, respectively, for the U.S., Adriatic, and Korean areas, with NOAA and DMSP polar-orbiting data used for all three areas. Ground truth data will be provided by meteorological METAR (aviation routine weather report) observations.

The above data sources will be integrated and data relationships will be obtained through the knowledge discovery from databases (KDD) process. KDD provides a means by which data can be merged, studied, and dependencies determined. One of two databases (Figure 1) produced from the data will be explored with data mining tools to determine the appropriate relationships. This “KDD” database will consist of NWP, satellite, and observed data aligned, geographically and temporally, with the individual, surface, ground-truth observational stations. A second, visualization database will consist primarily of 2-D planar displays of the KDD variables across the FAs. As part of the complete KDD process, the visualization database will allow us the means to add and refine the variables chosen for the KDD database.

<b>Report Documentation Page</b>			Form Approved OMB No. 0704-0188	
<p>Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p>				
1. REPORT DATE <b>SEP 2000</b>	2. REPORT TYPE	3. DATES COVERED <b>00-00-2000 to 00-00-2000</b>		
4. TITLE AND SUBTITLE <b>Satellite/NWP Data Fusion for Weather Assessment</b>			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Research Laboratory,,Monterey,,CA,93943</b>			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>5</b>
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>		

Once the KDD database consists of at least several months of data, we will start to apply data mining tools to the database for the purpose of producing a cloud-base height superior to that from NWP methods alone.

Project team:

Paul M. Tag—team leader, TAMS-RT

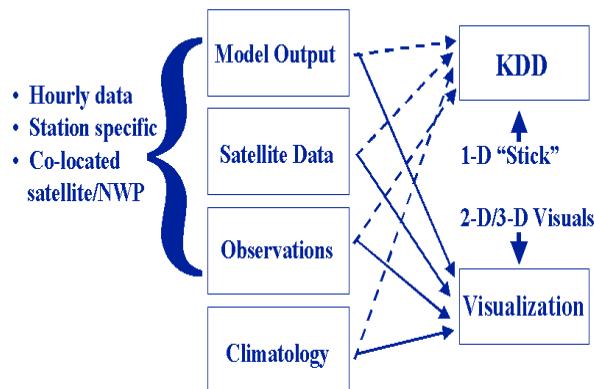
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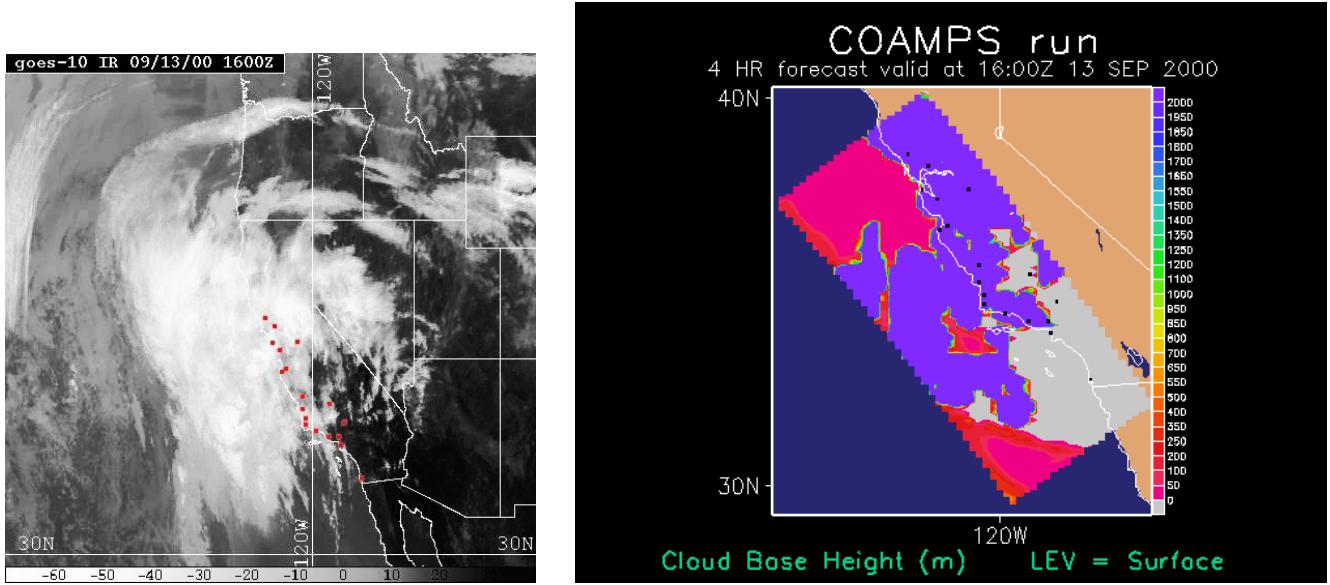
**Figure 1. Two databases: one for KDD (knowledge discovery) purposes and a second for visualization.**

## WORK COMPLETED

A unique meteorological research environment has been designed, built, and put into operation. This environment brings together conventional surface observations, satellite data, and numerical weather prediction data for specific locations into one database. These locations were chosen to coincide with specific METAR stations within three different focus areas (FAs) for which a triply-nested COAMPS is run twice daily.

We are now populating this massive database containing satellite, numerical weather prediction, and observational data: 1) near real time geostationary and polar orbiter satellite data; 2) COAMPS model data from model runs for the three FAs—the U.S. west coast, the northern Adriatic, and Korea (these tests have revealed several model setup/processing issues that were then resolved by the modeling community and in turn assisted the COAMPS effort); and 3) ground truth observations, where there are between 13 and 18 surface stations for each FA. The results of this data collection/assimilation process actually take two forms: 1) a DBMS-type database that will be used for knowledge discovery and contains all associated NWP and satellite stick (1-D) information corresponding to the ground-truth surface locations, and 2) 2-D (planar) visualizations that will be used by the project members on a daily basis to monitor and study the parameters of interest. This visualization process is key to

understanding and determining parameters important for data fusion through the data mining process. See Figure 2 for examples of both satellite and COAMPS visualization products.



**Figure 2. Examples of U.S. west coast visualization products. The satellite image on the left is an infrared image taken from the GOES satellite (9/13/00; 1600 UTC). The 2D display on the right is COAMPS output (9 km inner-most grid) of cloud base height that is valid at same time as the GOES image (gray areas indicate no clouds). Note the dots (on both images), corresponding to ground-truth observation stations (METAR stations).**

## RESULTS

As of this writing, we have been populating the database for only two months; however, certain conclusions are already forthcoming. First, a nine-kilometer fine-grid resolution is inadequate for those coastal locations located within 9 kilometers of the shoreline. There, meteorological gradients of temperature and cloudiness occur at scales much finer than nine kilometers. Beyond the first 10 kilometers, horizontal resolution is less an issue. Second, errors in predicted ceiling from the COAMPS model indicate that satellite data are critical to further fusion efforts. For those instances where the model does predict a ceiling, both the Adriatic and Korean domains have a very high percentage of overpredicted ceilings (too high). The west coast domain has a higher percentage of underpredicted ceilings. These types of biases, if well defined by region, will provide valuable feedback to model developers.

## IMPACT/APPLICATIONS

The potential for producing improved analyses of tactical weather parameters by using KDD applied to combined NWP and remotely sensed databases would be a key scientific development for the meteorological community. Because cloud base height is, arguably, the key parameter affecting tactical air operations, the ability to produce improved cloud base heights would be of vital use during any training exercise or conflict.

## **TRANSITIONS**

Results from this ONR project would transition via 6.4 funding (SPAWAR, PMW-185, task X-2342) to produce an operational product to be used at FNMOC, regional centers, and Navy facilities.

## **RELATED PROJECTS**

This work builds upon expertise developed with ONR PE 602435N funding. In FY98, that effort involved a preliminary knowledge discovery project linked to COAMPS data. Other artificial intelligence (AI) work funded by ONR through the NRL 6.2 base program in FY98 included the 1) development of fuzzy wind forecast rules for specific Mediterranean ports and 2) the use of computer vision to assess the intensity of tropical cyclones from satellite data. AI funding in 6.4 (SPAWAR, PE 603207N) has led to the transition of an expert system for wind forecasting in the Mediterranean (MEDEX). MEDEX is used at the Rota, Spain METOC center and aboard ships operating within the Mediterranean.

Additional AI efforts have been undertaken with regard to successful automated cloud classification algorithms. Close contact is maintained with the artificial intelligence group at NRL DC, the remote sensing group at NRL Stennis, and we are collaborating with an ONR-funded effort at the Desert Research Institute to study forecast model applications of satellite-derived cloud parameters.

This effort leverages the extensive ongoing efforts at NRL Monterey in both satellite remote sensing and mesoscale numerical modeling. The capability to utilize the spin-offs created from 6.1/6.2/6.4 programs has been crucial in permitting the building blocks for this project to come to fruition. And experience gained by this team in executing TAMS-RT and evaluating the COAMPS products has provided valuable feedback to the model developers.

## **PUBLICATIONS**

Tag, P. M., R. L. Bankert, M. Hadjimichael, A. P. Kuciauskas, W. T. Thompson, and K. L. Richardson, 2000: Applying knowledge discovery from databases (KDD) to combined satellite and high resolution numerical model data. Proceedings, Second Conf. on Artificial Intelligence (Joint with 10<sup>th</sup> Conference on Satellite Meteorology and Oceanography), American Meteorological Society, 45 Beacon St., Boston, MA 02108, 78-83.